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Intercomparison of High-Volume PM10 Samplers at a Site with High Particulate Concentrations

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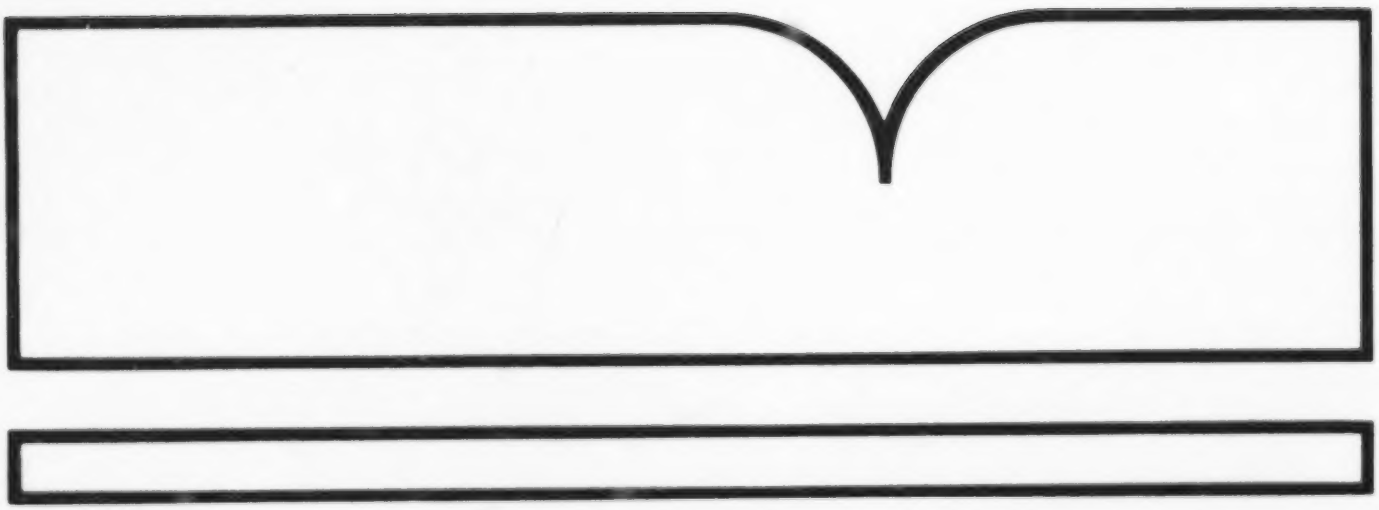

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16. ABSTRACT
Commercially available high-volume PM_{10} samplers were intercompared at a site in Phoenix characterized by high concentrations of coarse particles. Over a 21-day period, SierraAndersen 321A (SA 321A) samplers gave PM_{10} measurements 58% higher than the Wedding IP_{10} (WED) samplers and 16% higher than a SA 321A sampler that had an oil coating on the internal impaction surfaces of the inlet. WED samplers that were subjected to a simple brush cleaning procedure after each sampling period gave PM_{10} results 16% higher than the WED samplers not subjected to cleaning. The oiled SA 321A sampler gave PM_{10} values 15% higher than the cleaned WED samplers. The results demonstrate that the SA 321A overestimates PM_{10} when sampling in an environment with high coarse particle concentrations. The overcollection results from pass-through of large particles, and can be minimized by oiling the internal impaction surfaces of the inlet. The WED sampler underestimates PM_{10} after several days of sampling in such an environment. The undercollection results from the buildup of particles on the internal collection surface of the inlet, but can be minimized by periodic cleaning. The oiled SA 321A inlet was also affected by soiling, suggesting that periodic cleaning (and reoiling) is necessary. The cleaning procedure used on the WED inlets may not have been adequate to eliminate the soiling effect completely. Manufacturers of these inlets are urged to develop appropriate inlet maintenance procedures or other corrective action to minimize the impact of these problems on future PM_{10} measurements.

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JOURNAL ARTICLE

Intercomparison of High-Volume PM_{10} Samplers at a Site with High Particulate Concentrations

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In a recent evaluation of commercially available PM_{10} samplers by Rodes *et al.*,[1] the two available high-volume samplers—the General Metal Works Model 9000 (GMW 9000) developed by Wedding *et al.*[2] and the Sierra Andersen Model 321A (SA 321A) developed by McFarland *et al.*[3]—produced PM_{10} concentration measurements that were in substantial disagreement when sampling in areas with high concentrations of coarse particles. For example, in suburban Phoenix, mass concentrations obtained with SA 321A samplers were 36 percent higher on average than those obtained with collocated GMW 9000 samplers. Rodes *et al.* proposed that the observed differences were primarily the result of undercollection by the GMW 9000, brought about, in part, by the excessive build-up of particles on the oiled, internal collection surface of the cyclone inlet. It was subsequently postulated that these particles protruded into the air stream and intercepted particles that should have been transmitted to the filter.

In a critical review of the Rodes study, Wedding *et al.*[4] concluded that the differences resulted from the overestimation of PM_{10} concentrations by the SA 321A due to large particle pass-through and enrichment at elevated wind speeds. To support this conclusion, the authors cited results from their own field study[5] at a site with high concentrations of coarse particles. They reported that oiling the internal impaction surfaces of the SA 321A inlet substantially reduced the mass transmitted to the filter and attributed this reduction to decreased pass-through of large particles. Lee *et al.*[6] examined sample filters from the Wedding study, using scanning electron microscopy, and found more large particles on the filters of an unoiled SA 321A sampler than on those of collocated GMW 9000 and oiled SA 321A samplers.

McFarland and Ortiz[7,8] subsequently conducted both wind tunnel and field tests on the inlets in question. They suggested that the differences in PM_{10} measurements obtained in the field with the GMW 9000 and the standard SA 321A (unoiled) were primarily due to the GMW 9000 inlet having a lower 50 percent cutpoint, which is further reduced as the inlet becomes soiled. They also concluded that the observed differences in performance between the oiled and unoiled SA 321A inlets resulted from the same phenomenon previously postulated for the GMW 9000 (i.e., increased deposition of particles on the particle-laden impaction surface of the oiled inlet), and not from large particle pass-through in the unoiled inlet.

In an effort to resolve this controversy, EPA conducted an additional investigation at the same site in Phoenix where the maximum disagreement between the two samplers was observed. The purpose of this study was to inves-

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tigate the effects of soiling (particle accumulation) on a new, Wedding-modified version of the GMW 9000 and ascertain to what extent large particle pass-through occurs in the SA 321A. Because of the large number of GMW 9000 and SA 321A inlets currently in use and the strong interest in resolving this controversy, the pertinent preliminary observations from this investigation are reported briefly herein to facilitate the timely transfer of this information to the user community. A more definitive report describing the experiments in detail and presenting a complete analysis and interpretation of the study results will follow.

The field sampling was completed in May 1986 and primarily involved the comparison of PM_{10} measurements obtained with Wedding-modified GMW 9000 inlets (cleaned and uncleaned) and SA 321A inlets (oiled and unoiled). In the modified Wedding inlet, the oiled, plastic surface of the GMW 9000 is replaced with an oiled, sintered metal surface. In addition, the inlet is redesigned to provide convenient access to the primary internal collection surface for periodic cleaning. The new inlet is identical to the GMW 9000 in all other respects and is herein referred to as the WED inlet. Measurements were also obtained with a GMW 9000, two PM_{10} dichotomous, and several TSP high-volume samplers. Special short-duration samples were collected with each of the test samplers for subsequent microscopic examination to provide additional interpretive information.

The test samplers were placed on scaffolding, maintaining a 2-meter spacing between the sampler inlets. The diagonal distance across the sampler array was just over 10 meters. All inlet openings were at exactly the same height, approximately 3 meters above ground level. All of the inlets (except the dichots) were used with identical GMW Accuvol bases equipped with identical flow controllers and flow recorders. The samplers were calibrated initially using certified flow transfer standards (orifice-type), and flow checks were performed daily using the same standards. The samplers were operated with sample cassettes and quartz filters, and all filter weighings were performed on site. All mass concentrations were calculated based on

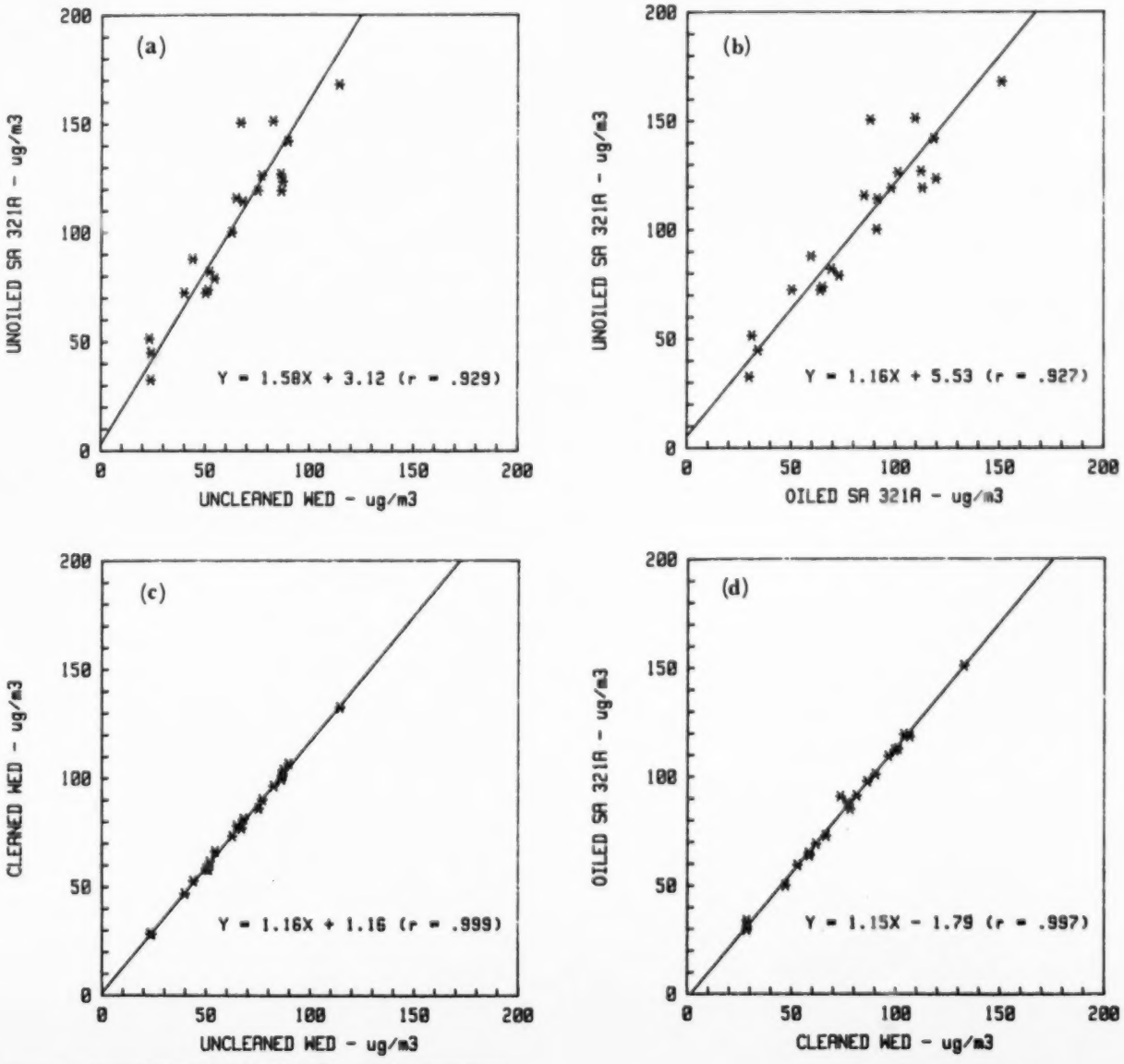

Figure 1. Regression plots for high-volume PM_{10} sampler comparisons.

the daily flow checks. Flow recorder data (Dickson charts) were used to verify sampler flow rate stability over the sampling periods.

Samples of 24-hour duration were collected on 32 sampling days. Duplicate WED inlets (uncleaned), duplicate SA 321A inlets (unoiled), and a single oiled SA 321A inlet were operated daily. Two additional WED inlets (cleaned) were operated about every fourth sampling day with simple brush cleaning after each 24-hour sampling period, until a significant difference (>10 percent) between the cleaned and uncleaned WED inlets was detected. After that point, the cleaned WED inlets were operated daily (with cleaning after each 24-hour sampling period).

The mean TSP concentration over the 32 sampling days was 206 $\mu g/m^3$ with a standard deviation of 75 $\mu g/m^3$. The mean PM_{10} concentration was approximately 85 $\mu g/m^3$ and the mean coarse to fine ratio, as measured by the dichotomous samplers, was 4.0. Precision estimates for the duplicate samplers were 2.5 percent for the cleaned WED, 3.5 percent for the uncleaned WED, and 4.0 percent for the unoiled SA 321A.

The salient sampler comparisons are presented as orthogonal regression plots in Figure 1. The data shown are for the 21 sampling days following initiation of the daily sampling and cleaning schedule for the two cleaned WED inlets. The points represent the average result for duplicate samplers, when appropriate. The unoiled SA 321A samplers collected about 58 percent more mass (40 $\mu g/m^3$ on average) than the uncleaned WED samplers, with substantial scatter in the data (Figure 1a). Similar results (within 10 percent) were obtained when data for all 32 sampling days were plotted. The unoiled SA 321A samplers collected about 16 percent more mass (19 $\mu g/m^3$ on average) than the oiled SA 321A sampler (Figure 1b). Again, the data were scattered, similar to that apparent in the first plot. The results for all 32 sampling days were almost identical in this case.

The cleaned WED samplers collected about 16 percent more mass (11 $\mu g/m^3$ on average) than the uncleaned WED samplers (Figure 1c), demonstrating the soiling effect proposed by Rodes, *et al.* Note that the data are very highly correlated. The oiled SA 321A sampler collected about 15 percent more mass (9.5 $\mu g/m^3$ on average) than the cleaned WED samplers (Figure 1d). Again, the data are highly correlated. This strongly suggests that the scatter in the first two plots is a result of a somewhat higher day-to-day variability of collection by the unoiled SA 321A samplers.

A third cleaned WED sampler was operated over the last 10 sampling days to determine whether daily cleaning of the first two cleaned WED inlets caused any change in the performance of the inlets due to depletion of the oil on the internal collection surfaces. If oil depletion was occurring, the first two samplers would be expected to give higher PM_{10} measurements due to particle bounce. However, just the opposite was observed—the third cleaned WED collected about 10 percent *more* mass (8 $\mu g/m^3$ on average) than the two original WEDs (cleaned). This suggests that the simple brush cleaning procedure used in this study did not deplete the oil, but may not have been vigorous enough to eliminate the effects of soiling completely.

A second oiled SA 321A sampler was operated over the last 16 sampling days to determine whether large particle pass-through was occurring in the first oiled SA 321A inlet after the build-up of significant particle accumulation on the oiled impaction surfaces. If large particle pass-through was occurring, the first oiled SA 321A would be expected to give higher results. Again, just the opposite was observed—the second oiled SA 321A collected about 6 percent *more* mass (5 $\mu g/m^3$ on average) than the original oiled SA 321A. This suggests that large particle pass-through probably is not a problem, but that decreased transmission of PM_{10} may be occurring due to the same soiling phenomenon evident in the WED inlets.

When the third cleaned WED was compared to the second oiled SA 321A over the last 10 sampling days, a difference of about 10 percent was observed. This difference is in agreement with predictions based on wind tunnel test data. Results from concurrent testing of the WED and SA 321A inlets with liquid particles in the EPA wind tunnel test facility in Research Triangle Park, North Carolina, indicate that the SA 321A inlet has a 50 percent cutpoint that is a little over 1 μm higher than that of the WED inlet. Expected mass collections calculated using the measured effectiveness curves for these inlets and ambient particle mass distributions representative of Phoenix predict differences in mass collections of about 7 to 9 percent, which is consistent with the observations in the field.

The results presented here indicate that the WED inlet exhibits an undercollection of particulate mass after several days of sampling in an environment characterized by high concentrations of large particles. The effects of soiling on the WED inlet can be minimized by periodic cleaning of the primary collection surface of the inlet. The SA 321A inlet exhibits an overcollection that is probably a function of the ambient particle size distribution and mass concentration, among other factors. Oiling the impaction stages of the SA 321A minimizes this overcollection and results in less variable performance. However, soiling of the oiled inlet appears to produce the same effect observed with the WED inlet, suggesting that periodic cleaning (and reoiling) will be necessary. Examination of the WED and SA 321A inlets at the completion of this study and the observed soiling effects support the postulation that particle accumulation on the oiled surfaces of these inlets reduces the transmission of PM_{10} particles through the inlets. Furthermore, the need for periodic cleaning of inlets which employ oiled collection surfaces is clearly demonstrated.

The differences observed between the oiled SA 321A and cleaned WED in this study are consistent with predictions based on expected mass calculations from wind tunnel inlet effectiveness data and ambient particle mass distribution data. These differences were 10 to 15 percent at a site in Phoenix where the coarse to fine particle ratios and TSP concentrations were very high and probably represent an upper bound for such collocated comparisons. Better agreement would be expected at sites with lower coarse to fine ratios and lower TSP concentrations.

The manufacturers of these inlets are encouraged to develop appropriate inlet maintenance procedures (i.e., cleaning, reoiling, etc.) to minimize or eliminate the problems reported here, and provide guidance or instructions to current users of the inlets on the proper application of these procedures. Users are encouraged to follow the recommendations provided by the manufacturers in order to minimize the impact of these problems on future PM_{10} measurements with these inlets.

The two available high-volume PM_{10} samplers evaluated in this investigation have been shown by their respective manufacturers to meet the EPA proposed performance requirements. The results of this study indicate that these two samplers will produce acceptable PM_{10} concentration measurements within predictable agreement provided the problem areas described in this paper are properly addressed. Based on these results, we also believe that EPA's proposal to specify PM_{10} samplers primarily by performance requirements and to formally designate acceptable PM_{10} monitoring methods based on wind tunnel test data is still the most viable and flexible approach for prescribing acceptable monitoring methods. However, the federal reference method for the measurement of PM_{10} concentrations in the atmosphere needs to address requirements for periodic maintenance of inlets.

References

1. C. E. Rodes, D. M. Holland, L. J. Purdue, K. A. Rehme, "A field comparison of PM_{10} inlets at four locations," *JAPCA* **35:** 345 (1985).
2. J. B. Wedding, M. A. Weigand, "The Wedding ambient aerosol sampling inlet (D50 = 10 microns) for the high-volume sampler," *Atmos. Environ.* **19:** 535 (1985).
3. A. R. McFarland, C. A. Ortiz, R. W. Bertch, Jr., "A 10 μm cutpoint size selective inlet for hi-vol samplers," *JAPCA* **34:** 544 (1984).
4. J. B. Wedding, J. P. Lodge, Jr., Y. J. Kim, "Comments on 'A field comparison of PM_{10} inlets at four locations'," *JAPCA* **35:** 649 (1985).
5. J. B. Wedding, M. A. Weigand, Y. J. Kim, "Evaluation of the Sierra-Andersen 10 μm inlet for the high-volume sampler," *Atmos. Environ.* **19:** 539 (1985).
6. R. J. Lee, C. C. Fisher, J. F. Kelly, J. S. Walker, "Comments Pertaining to 40 CFR Part 53 and 40 CFR Part 50, Appendix J," submitted to Central Docket Section, U.S. EPA, U.S. Steel Corporation Technical Center, Monroeville, PA, 1985.
7. A. R. McFarland, C. A. Ortiz, "Response to comment on 'A field comparison of PM_{10} inlets at four locations'," *JAPCA* **35:** 950 (1985).
8. A. R. McFarland, C. A. Ortiz, "Sampling Anomalies of the 40-cfm Wedding Aerosol Sampler," Texas A & M University, Air Quality Laboratory Report 4716/01/06/85/ARM, College Station, TX, June 1985.

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